SSC Pacific Scientists Perform Studies to Support a New Apra Harbor Discharge Permit

Efforts Include Mixing Zone Analysis, Recalculation Procedure & Other EPA Methods

A MULTI-YEAR COOPERATIVE effort between personnel from the Naval Facilities Engineering Command (NAVFAC) Marianas and the Space and Naval Warfare Systems Center Pacific (SSC Pacific) has placed U.S. Naval Base Guam's Apra Harbor Wastewater Treatment Plant (WWTP) on a clear path to compliance.

In 2005, the Navy's Apra Harbor WWTP was placed on the U.S. Environmental Protection Agency's (EPA) Significant Non-compliance (SNC) list for violations of its National Pollution Discharge Elimination System (NPDES) permit. This SNC designation indicates a serious level of violation as noted in EPA databases.

In June 2010, NAVFAC Marianas entered into a Federal Facilities Compliance Agreement (FFCA) with EPA for the plant as part of a proactive approach to achieve NPDES compliance. Concurrently, NAVFAC Marianas engaged the environmental sciences division at SSC Pacific to request technical assistance in achieving compliance.

In consultation with NAVFAC Marianas, SSC Pacific developed a technical approach to meet the requirements of the FFCA in a timely, technically sound and cost-effective manner. The scientific approach considered the outdated and unachievable discharge limits set by the 2001 Guam Water Quality Standards and pertinent EPA guidance documents to the develop site-specific permit limits.

Assessing Compliance

Before any work began, the SSC Pacific team and NAVFAC Marianas discussed their methodology with EPA and Guam EPA. Considering the long-standing SNC violations and other historical factors, getting the regulators to "buy in" to the scientific principles at work was challenging. It took strategic and cooperative team efforts consisting of multiple face-to-face meetings, presentations and negotia-

Aerial view of Tipalao Bay.
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tions with the regulators to gain their willingness to consider SSC Pacific's scientific approach. These collaborative efforts proved to be an important first step, and were vital in streamlining the regulatory process and incorporating the study results into the final permit.

Adhering to EPA guidance throughout the project, the SSC Pacific team had three overarching goals:

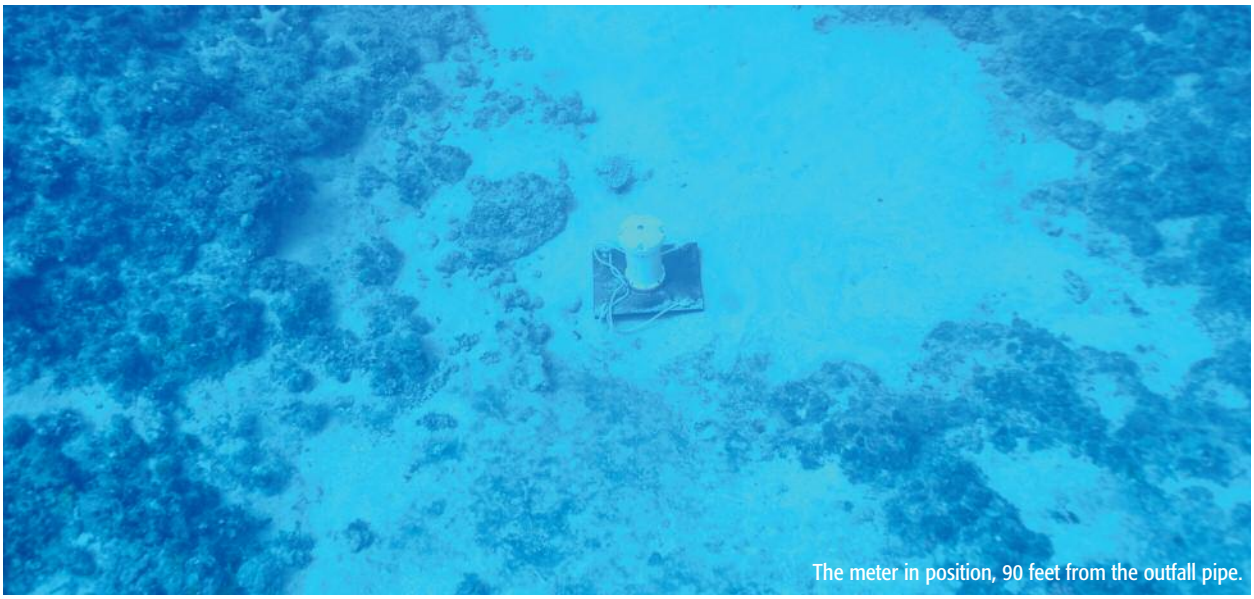
1. Validate a mixing zone.
2. Develop site-specific criteria for copper, nickel and aluminum.
3. Verify clean chemistry procedures so that sampling numbers are accurate and precise.

According to EPA's Technical Support Document "USEPA-505-2-90-001," a triad of approaches should be used to assess water body health: whole effluent, chemical-specific, and biological assessments. In other words, what specifically is in the effluent (outfall), how does it affect living organisms, and how well does it mix into adjacent receiving waters?

The Mixing Zone Analysis

In multiple situations, EPA and State regulations allow for the use of a mixing zone to determine points of

The diffuser at the end of the outfall pipe.



The meter in position, 90 feet from the outfall pipe.

No one had ever looked at it and said, "Wait a minute, this isn't appropriate."

–Pat Earley

regulatory compliance within a waterbody at a set distance away from the end of a discharge pipe. A mixing zone is described by the EPA as "a limited area or volume of water where initial dilution of a discharge takes place and where numeric water quality criteria can be exceeded." It is important to note that EPA has never approved a mixing zone for Guam. Upon approval, this will be the first such approval.

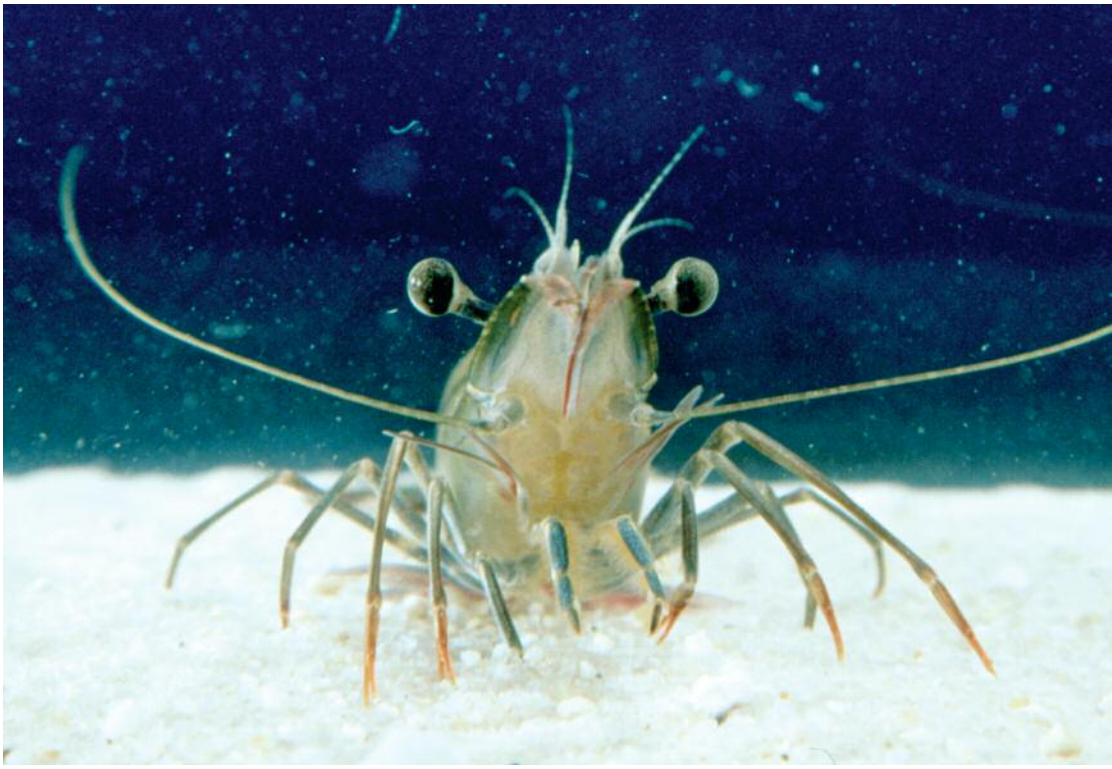
To make this determination, a model was needed. The team chose the Cornell mixing zone model known as CORMIX. This EPA-accepted model was used to simulate the discharge environment and evaluate the behavior of the plume from the industrial submarine outfall into Tipalao Bay, Guam.

The CORMIX modeling framework uses existing data on the physical characteristics of the discharge, flow volume and contaminant characteristics of the effluents, ambient hydrodynamic conditions and contaminant levels, and other discharge characteristics to simulate theoretical steady-state discharges from the wastewater treatment plant. This allows for estimates of the size of the mixing zone that would be needed to meet water quality standards under a wide range of environmental conditions. To supply the data needed for the modeling tool, the team deployed an Acoustic Doppler Current Profiler (ADCP) to take three-dimensional measurements through the water column and capture the direction and velocity of the different ambient currents.

"In any given location, currents don't all flow in the same direction or at the same speed," said Pat Earley, SSC Pacific's environmental science branch head. "The top may be flowing north to south. Twenty feet lower it could be flowing due west."

The meter was positioned 90 feet from the end of the discharge pipe. This distance was based on a decision to be close enough to characterize the currents that would affect the outfall, but far enough away so that it wouldn't be influenced by the outfall itself.

With the data provided by the ADCP and other parameters, the CORMIX tool validated the mixing zone conditions at the specified distance. The range of modeling parameters was run through multiple scenarios. Selection of the most environmentally conservative combination of these parameters, (e.g., no current and high discharge rate) predicted a minimum dilution factor of 29.7 at the edge of the mixing zone. "This value is applied to the permit limits," said Earley.



The Tiger Shrimp (*Penaeus monodon*) is one of the new species added to the database for Guam.
Courtesy of Wikipedia Commons

The Lace coral (*Pocillopora damicornis*) is one of the new species added to the database for Guam.
Ahmed Abdul Rahman

"It's a divisor that demonstrates you are protective of the environment and meeting water quality criteria within the mixing zone given the worst possible combination of environmental and discharge conditions."

Discussing real world scenarios, Earley added, "If we took the average dry weather conditions, which are usually occurring at this outfall, and the tenth percentile ambient current, which is still conservative, water quality standards are met within 20 feet from the outfall diffuser." (Note: The diffuser is an attachment on the end of the outfall pipe, where the effluent gets into the surrounding water.) Utilizing the most conservative parameters, the team calculated the hypothetical amounts of copper, and nickel that would have to be discharged to exceed the water quality criteria: copper at 115 micrograms per liter; nickel at 566 micrograms per liter. These concentrations are higher than have ever been measured associated with the Apra Harbor Discharge.

Removing Aluminum

"We started investigating the water quality criteria for aluminum and realized that it was essentially an error," stated Earley. Back in 1988, the wastewater treatment plant's NPDES permit was assigned a 200 microgram per liter limit for aluminum discharge. However, that figure was based on fresh water standards. EPA has never established saltwater water quality standards for aluminum. "They incorporated these criteria into the Guam Water Quality Standards a long time ago," said Earley. "No one had ever looked at it and said, 'Wait a minute, this isn't appropriate.' Once we showed it to the regulators, they agreed to reconsider this criteria in the next permit and in the Guam Water Quality Criteria."

This finding may have implications for Florida Navy facilities as well because Florida's standard for aluminum discharge is also based on the outdated freshwater standard.

Site Specific Criteria

Each water quality standard is set based on a national database that includes hundreds of tests on organisms, organized by genus and species, some of which may not be present in Guam. In order to customize the permit to the discharge environment, the team chose to follow an EPA-approved mathematical method known as the recalculation procedure. While state EPA offices are not obligated to recognize this scientifically defensible approach, Guam EPA was completely open to

Dr. Ignacio Rivera and Gunther Rosen, members of the SSC Pacific project team, perform standard toxicity tests on the Long Spined Urchin.

its use. "The recalculation procedure allows you to make permit limits site specific," Earley said.

The procedure is a step-wise method that involves corrections, additions, and deletions to the national toxicity data set, rendering it more representative of species occurring at a specific site.

The first step in the process was to make corrections to existing datasets. In some cases, the SSC Pacific team found mathematical errors in EPA datasets. In other cases, outdated science was being cited. For example, the Water Quality Criteria (WQC) being cited in the plant's existing permit was based on 1995 standards. However, in 2012 a revision was proposed which incorporates a large number of corrections and a much larger dataset (over three times the number of species).

Earley explained how WQC limits are calculated. "For each data set, a dose/response curve is plotted and some conservative calculations are applied to derive a water quality criterion that provides for protection of 95 percent of the aquatic community 95 percent of the time."

The team conducted an extensive review of species present in the Marianas region. It was discovered that the most sensitive species under the old criteria was the Blue Mussel. Earley's team was able to remove this species because it does not exist in the waters around Guam. Similarly, some species were added that were unique to Guam—species that were not in the national database. In fact, so many new species were added to the dataset that it expanded from a total of 26 to 67 individual organisms. Conventional wisdom might expect the limits to go down in this case, but after running the calculations the limit levels for copper and nickel actually increased.

"It's not easy to actually revise numbers upward," Earley said. "You have to bring a lot of science to the table to show them that we're not being less environmentally protective."

When recalculating the numbers for nickel, the team went out and collected samples of a local genus to supplement the data. "We didn't have any data for the local Long Spined Urchin," Earley said. "So in cooperation with the University of Guam, we went out and collected this local organism and performed standard toxicity tests on it," he said. "Following the rules in the EPA guidance document, we replaced the Long Spined Sea Urchin that was in the database with another variety, *Diadema antillarum*." Results were published in a scientific peer-reviewed publication Bulletin of Environmental Contamination and Toxicology (Volume 95. Number 1, pages 6 to 11, 2015). This addition renders the criteria more appropriate for Guam in particular, and the Marianas region overall.

The new copper limits proposed by the team are 4.9 micrograms per liter for acute (at the end of the pipe) and 9.9 micrograms per liter for chronic exposure. These figures are based on total recoverable levels of the metal, which is the measure EPA generally uses to determine toxicity of a water body. There are two ways to measure metals. Earley explained, "The total recoverable form includes metal bound-up to particulates that don't cause toxicity to organisms (they are not bioavailable). The dissolved form is what enters into

cell walls and kills the organisms." EPA recognizes that the dissolved fraction of metals better represents the bioavailable portion of the metal in natural waters, so following EPA guidance, the team converted total recoverable metal levels to dissolved metals to more accurately describe potential environmental toxicity. In the case of copper, it was determined that 57 percent of the metal was bioavailable—the rest was bound and essentially harmless to aquatic life. In the case of nickel, it was 77 percent bioavailable.

"We try to attain early agreement with the regulators and make the case that we'll apply the science and whatever the numbers are, we should all accept them. We're not trying to simply get our permit levels raised. The Navy is willing to go through the extra costs and efforts to follow EPA guidance and develop site-specific criteria that are protective of the environment. We just follow the science and accept the numbers."

Sampling Techniques

In order for samples to be reliable, clean sampling techniques are essential. Clean sampling refers to all the parameters that might affect water sample quality, from ensuring that laboratory conditions are pristine to controlling conditions during sample collecting. According to Earley, "It takes a tiny particle to contaminate a sample and make it look like you have a much higher concentration."

After discussing proper techniques, SSC Pacific and Guam performed sample splitting, where each laboratory would run identical water samples. "We split samples with them and were able to inform their techniques and processes so that their data gained precision and reliability," Earley reported.

The Bottom Line

The results of this study suggest that the near-shore areas around the island of Guam are not impaired for copper or nickel. Effluent concentrations at the end of the pipe would have to increase by 10 times more than the highest ever reported values in order to impact water quality beyond the established mixing zone. The findings are supported by an absence of significant toxicity in any of the laboratory tests with the most sensitive species in EPA's species sensitivity distribution.

The current draft permit contains provisions that allow for a mixing zone, new discharge limits for copper and nickel as well as the removal of aluminum from the permit requirements. This successful effort has resulted in a scientifically defensible NPDES permit that is achievable and has removed the Apra Harbor Wastewater Plant from EPA's SNC list. "Getting early regulatory concurrence on our approach was crucial," concluded Earley.

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Looking Ahead

All of the work performed by the team to evaluate copper and nickel toxicity has larger implications than the outfall from the wastewater treatment plant in Guam—it's applicable to the entire Marianas region, and will be incorporated into the triennial review of Guam Water Quality Standards, a required process by which states or territories collaboratively review and update water quality standards.

Additionally, the team's methods, including consideration of dissolved versus total recoverable levels of metals, site-specific additions and deletions to the species database, and clean sampling techniques, are applicable to NPDES permit holders throughout the Navy. Coupled with the availability of the Biotic Ligand Model, currently under review, Navy facilities will be armed with new scientifically defensible tools to streamline permit negotiations, be protective of the environment, and meet environmental compliance requirements.

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